THEORETICAL FUNDAMENTALS OF ADSORPTION METHOD OF GAS SEPARATED FROM BITUMINOUS CONCRETE FACTORIES

[1]S.M. Boboev,
[2]H.R. Burkhonov,
[3]M. S. Ravshanova
[1]d.t.s. professor, [2]senior teacher , [3]student
Samarkand State Institute of Architecture and construction

ABSTRACT

The article deals with the adsorption method of gas purification impurities before emissions into the atmosphere emitted from the bituminous concrete plants production, as well as the balance equation and kinetic laws in the adsorption process.

Keywords: *adsorbent, porous, solid materials, activated carbon, silica gel, alumogel, zeolite, ionite, expanded clay.*

1. Introduction

At present, in addition to large amounts of dust from industrial enterprises, gas emissions are also released into the environment.

In particular, natural gas and fuel oil are used as fuel in the stone and sand drying and burning process in the drying drum in the preparation of asphalt from bituminous-concrete plants, resulting in the release of dust and gases.

Dust is mechanically removed using a dry powder processor - cyclones. However, the released gases, i.e. nitrogen oxides, sulfur, hydrogen oxides, carbon monoxide, are released into the atmosphere without purification [1].

2. Material and method

There are absorption, adsorption, catalytic and thermal methods of gas purification. The adsorbent method is used when the purifying component in the gases is not very high.

Porous solids are used as adsorbents. These materials come in both natural and synthetic form. The adsorbent is divided into mezo (variable) and micro-porous types, depending on the porosity size. The pores volume indicator relative to the unit mass is taken into account in the gases purification. Typically, the porosity does not exceed 0.5 cm^3/g. Their size is conditionally limited by the effective radius index and this $r_{S=}$ $1.5 \cdot 10^{-9}$m radius is proportional to the r_s radius of the adsorbed molecules.

3. Obtained results

The mezo (variable) pores radius varies from $1.5 \cdot 10^{-9}$m to 2.10^{-7}m. The surface area of mezo-porous adsorbents used in industry is in 10-400 m^2/g range. The macroscopic radius of industrial adsorbents is around $2-10^{-7}$m and the surface is $0.5-2 m^2/g$.

Industrial adsorbents include activated carbon, silica gel, alumogel, zeolite and ionites. The adsorbents will have a true apparent and gravimetric density, the actual density px being the unit mass of the adsorbent density without pores, determined as follows:

$$p_x = \frac{G}{V1 - V2}$$

G –adsorbent mass, kg
V₁–adsorbent volume, m^3
V₂- the size of the pores, m^3

The apparent density p_T is the ratio of the adsorbent mass granule to its volume. The gravimetric density p_G is the mass ratio per unit the adsorbent volume to that layer. Gravimetric and imaginary densities are related to the adsorbent porosity layer - ε, this quantity indicates the percentage of free volume of the layer and is determined by the following positive:

$$P_H = 1 - ε / p_R,$$

therefore, $ε = 1 - p_G / p_K$,
where: **ε-** is a free volume between layers (porosity)
P_K– is 1 granule density, i.e. the granule mass ratio to its volume.

Generally, industrial adsorbent granules do not have to be spherical. Therefore, the diameter of the granules is a relative concept. The calculations use the equivalent diameter of the granule.

$$D_e = 6 / S_V,$$

where: **S_V** – is specific area of unit volume, m^2

The main adsorbents used in industry today include activated carbon, silica gel, alumogel, zeolite and ionite materials, we propose to include expanded clay material as well.

Activated carbon is a type of adsorbent widely used in industry. Its hydrophobic property is useful in the purification and recuperation of wet gases. It has brands AG-2, SKT, AR, SKT-3, ART. AG-2 and AR grades are obtained chemically from coal, SKT grades from peat, and SKT-3 and ART grades from peat and coal. AG-2 is used

for separation of gases from dust in adsorption; SKT- is used for vapors absorption of organic compounds, and AR, SKT-3, ART are used for purification of gases from volatile solvent vapors. Recently, activated carbon from polymeric materials, activated carbon fibers, activated carbon with molecular sieve are used for gas purification. {2,3}

Activated carbon obtained from a polymeric material has a permanent structure and has a high absorption property even in cases where the content of the purified gas is very low.

Activated carbon fibers are derived from synthetic fibers and have a micro-porous structure. They are much easier to use.

Silica gels are chemically hydrated amorphous substances(SiO_2 nH_2O). The pores volume of silica gels is 0.3-1.2cm^3/g, specific surface area is 300-700m^2/g, gravimetric density is 0.4-0.9g/cm^3.

Silica gels serve to absorb polar substances. Absorbs water vapor in the air well. Therefore, it is also widely used in the gases drying. But it is absorbed under the water drop influence (so this shortcoming of the adsorbent must be taken into account).

Alumogels (Al_2O $nH2O$) are obtained by firing aluminum hydroxide compounds. In this case, alumogels of different structures are obtained, depending on the original alumina, alkaline, alkaline earth metals composition. Typically in industry γ - Al_2O_3 structure is obtained.

Zeolites are composed of aluminosilicates, which contain both alkaline and alkaline earth metals. The zeolites structure is constant, and the pores diameter in them corresponds to the molecules diameter. This is why zeolites are sometimes called "molecular sieves." The general formula – $Me_{2n}O \cdot Al_2O_3 \cdot xSi_2O \cdot yH_2 O$ (Me – alkali metal, n- valence). Zeolites have solid inlet holes. Only molecules that are smaller in size, slightly smaller than the hole diameter, pass through the hole.

Zeolites are obtained both synthetically and from natural deposits. Synthetically derived zeolites are often used in gas purification. These include NaA CaA, NaX, CaX marks. The diameter of the incoming holes in each mark will be expressed in angstrom [$1A^0 = 21(10^{-9}m)$] units of measurement [there will be zeolites with 4,5,8 va $9A^0$ holes]. Zeolites have good adsorption properties. NaA brand zeolite is used in the gaseous wastes treatment with a molecular diameter of not more than $4 \cdot 10^{-9}$ m. These include H_2O, C_2S, CO_2, NH_3, diene and acetylene row hydrocarbons, C_2H_6, C_2H_4, C_3H_6 single metal group organic compounds CH_4, Ne, Ar, Kr, Xe, O_2, N_2, CO.

CaA brand zeolite is resistant to weakly acidic environments and is useful in cleaning from S-composite gaseous substances. This zeolite is also used to capture hydrocarbons and alcohols of normal structure. X-brand zeolites are used in the capture of all types of hydrocarbons, S, N, and O compounds, halogenated compounds. Their gravimetric density is 600-900 kg/m^3. Ionites are high-molecular substances that are not currently widely used in the treatment of industrial exhaust gases. But now they are being investigated for their use in trapping acidic substances in the gas (nitrogen and sulfur oxides, halogens, etc.).

The absorption or absorption capacity of adsorbents depends on the amount of substance absorbed per unit mass or volume, the nature of the substance absorbed, the temperature, the pressure, and the amount of mixture in the phase.

There is the following relationship between the equilibrium concentrations of the solids in the solid and gaseous or liquid phases process,

$\chi_M = f_1(y)$ еки $\chi_M = f_{2(}p)$;

χ_M –is the concentration of the absorbed substance in the adsorbent, ie the equilibrium concentration of the absorbed substances in the gas or liquid phases, the ratio of the absorbed substance in kg to 1 kg of adsorbent; У –is concentration of absorbed substance in vapor or liquid phase, ratio of kg absorbed substance to 1 kg inert part; P-is vapor is the equilibrium pressure of the absorbed substance in the gas mixture. N/m^2.

The bonds represented by the above formula are called adsorption isotherms. On the basis of chemical thermodynamics, precise expressions of adsorption isotherms are found.

Langmuir isotherms

$$X_M = abp/1+ap$$

or Freudlix isotherms

$$X_M = kp^{1/n}$$

X_M-is concentration of adsorbent absorbed, ratio of kg absorbed substance to 1 kg adsorbent, a,b,k,n - constants determined experimentally.

A decrease in temperature, an increase in pressure, and the additional impurities absence in the phases lead to an adsorption process acceleration. The type of adsorption isotherm depends on many factors. These include the specific adsorbent surface area, the pores size, the adsorbent structure, the adsorbent properties, and the process temperature. During the adsorption process, when several substances are adsorbed from the vapor or liquid phase, the absorption of all substances is determined. However, the equilibrium concentration of each substance is less than the concentration of each substance in separate adsorption.

During the adsorption process, the vapor pressure of the substance absorbed in the initial mixture decreases and heat is released, so according to the Le Chatele principle, the amount of adsorbed substance increases with decreasing temperature and increasing pressure. Thus, a decrease in pressure and an increase in temperature inversely accelerate the desorption process.

The amount of heat released during adsorption (kJ/mol) is determined experimentally. In the absence of experimental data, the amount of heat released can be found by the following formula. {4- Literature}.

$$r = \frac{19.16 ln \cdot p2/p1}{(1/T1)-(1/T2)}$$

where , p_1 and r_2 - corresponding absolute temperatures, equilibrium pressures of the absorbed substance on the adsorbent at T_1 and T_2.

The adsorption process does not differ from the mass transfer process in other solid phase systems. The adsorption process consists of the diffusion of the absorbed substance molecule from the gas stream to the outer surface of the adsorbent grain (external diffusion), compression of the molecule on the porous surface of the grain (internal diffusion), sorption (condensation) on the inner surface of the molecule grain. In this case, the final stage takes place at certain seconds - 10^{-8} - 10^{-9} C.

In general, the process of diffusion of the absorbed substance in the adsorbent is expressed using the criterion equation.

The equilibrium in adsorption is determined by the following equation.

$$\bar{X}=K \cdot P^{1/n} \qquad \bar{X}=aвp \, / \, 1+ap \qquad \bar{X}=A\bar{y}^{1/B}$$

$\bar{X}$- the concentration of the substance absorbed into the adsorbent, kg / kg;

R – equilibrium pressure of the absorbed substance in the gas mixture, Pa (pascal);

$\bar{\gamma}$- equilibrium concentration of the absorbed substance in the gas mixture; kg / kg, L, n, a, v, A, V – results determined from experience.

The material balance of adsorption is determined by the following formula.

Gd=Ldx

G- gas phase consumption, kg/h

L- adsorbent consumption, kg/h

У- working concentration of the substance in the gas phase, kg/kg conditional part

X- the working concentration of the substance in the adsorbent is kg / kg in the adsorbent.

For a periodic process, the concentration of the adsorbent in the adsorbent varies with time. In it, the material balance is determined as follows:

-Gdyd$_{\bar{i}}$ =SdH$_H$dx

S – cross-sectional area of the adsorbent, m^2

N- the height of the adsorbent layer, m

r_{H-} the scattering density of the adsorbent kg/m^3

The mass transfer equation is as follows

dH=K$_G$(y-y$_p$)dF

The mass transfer coefficient is related to the mass transfer coefficient.

$$1/K_G=1 \, / \, \beta_1 + 1 \, / \, \beta_2$$

The mass transfer coefficient for the external diffusion limit is calculated by the following equations.

$N'_U=0.39Re^{0.64} \cdot (Pr)^{0.33} \quad Re>30$

$N'_U=0.725Re^{0.47} \cdot (Pr)^{0.33} Re=2:30$

$\quad N'_U=0.51Re^{0.85} \cdot (Pr)^{0.33} Re<2$

The working height of the adsorbent layer at time $\tilde{\iota}_0$

$$N_0=N_0h$$

where: N_0– Number of units moved: h - unit carrying, height

$$h=G/SK_G \qquad N_0 = \int_X^H dx/x' - x$$

the cross-sectional area of the adsorbent

S=G/Ѡ·p_{cm}

G- gas consumption, kg/sec

Ѡ- gas velocity m/sec

p_{CM} – mixture density

apparatus diameters:

4. Discussion

The use of expanded clay as a 2-stage gas treatment plant in the bituminous -concrete plants of the Samarkand regional roads unitary enterprise was discussed and recommended for implementation.{6- Literature }.

5. Conclusion

The introduction of new material in increasing the cleaning efficiency of gaseous wastes at high temperatures and has a positive effect on reducing the greenhouse effect layer of harmful substances in the atmosphere. {6- *Literature* }

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